

## TITLE

**[0001]** Power conditioner and backup for security scanning equipment.

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0002]** This application claims the benefit of U.S. Provisional Application No. 60/441,609 filed January 22, 2003, which is hereby incorporated in its entirety.

## BACKGROUND

**[0003]** Ordinary utility power is subject to a number of problems. The first of these problems is outages, in which power is entirely interrupted to a customer for a period of minutes to days. Another problem is termed "brownouts", in which power is supplied to a customer at a lower voltage than specifications would normally permit.

**[0004]** A customer may provide an auxilliary short-term power source to mitigate these problems. A common auxilliary power source is a generator, for example powered by a diesel fuel engine, which can be started in the event of an outage or brownout. Another auxilliary power source that has become common in recent years is the Uninterruptible Power Supply, or UPS. UPS systems, rather than having a generator, typically utilize a solid-state inverter powered from batteries, lead-acid being a common battery type. For certain applications, such as powering resistive loads and non-electronic loads, these systems may be adequate to retain electrical equipment functionality without large inconvenience.

**[0005]** Other problems may exist with ordinary utility power. Spikes and dips may occur, for example, through the switching of circuits and the powering of motors near the point of power consumption, or the switching of mains circuits in the power distribution network. Noise may also be introduced on the power lines by "dirty" electronics, motor brushes and modified-sine wave inverters. Variations in voltage level and frequency may also occur, particularly where power is

supplied from an auxillary generator. Power may be interrupted to important electronic equipment for periods in duration from tens of milliseconds to even seconds, which may be mitigated at the equipment level by large reservoir capacitors and other techniques. Electronic equipment may be supplied with overvoltage as well, which may lead to premature equipment failure.

## BRIEF SUMMARY

[0006] The claimed inventions relate generally to UPS systems and equipment for conditioning utility power and more particularly to a three phase power conditioner operable at 400 or 480 VAC including an AC to DC converter, two banks of batteries, an internal battery charger, a high frequency DC to AC power inverter and passive filters for filtering input and output power.

[0007] Disclosed herein are power conditioning systems for providing filtered, clean and reliable power to sensitive electrical or electronic loads and further to provide battery backed power to those loads. Further disclosed herein are such power conditioning systems for supplying clean power to security scanning equipment and to infant life support devices. Detailed information on various example embodiments of the inventions are provided in the Detailed Description below, and the inventions are defined by the appended claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 depicts an outlet box of a first exemplary Uninterruptible Power Quality (UPQ) unit.

[0009] Figure 2 depicts a charger outlet panel of the first exemplary UPQ unit.

[0010] Figure 3 depicts an inverter inlet box of the first exemplary UPQ unit.

[0011] Figure 4 depicts a charger adapter plate of the first exemplary UPQ unit.

[0012] Figures 5a and 5b depict two charger cover plates of the first exemplary UPQ unit.

[0013] Figure 6 depicts an inverter inlet panel of the first exemplary UPQ unit.

[0014] Figure 7 depicts several parts in assembly position of a second exemplary UPQ unit.

[0015] Figure 8 depicts several sheet metal parts in assembly position of the second exemplary

UPQ unit.

- [0016] Figure 9 depicts the base cabinet portion of the second exemplary UPQ unit.
- [0017] Figure 10 depicts the top cover of the second exemplary UPQ unit.
- [0018] Figures 11a and 11b depict two filter cartridges of the second exemplary UPQ unit.
- [0019] Figure 12 depicts the PCB retainer block of the second exemplary UPQ unit.
- [0020] Figure 13 depicts an installation environment of the first exemplary UPQ unit.
- [0021] Figure 14 depicts one internal configuration for a UPQ unit.
- [0022] Figure 15 depicts the rear of a third exemplary UPQ unit.
- [0023] Figure 16 depicts several sheet metal components of the inverter portion of a fourth exemplary UPQ unit.
- [0024] Figure 17 depicts the base component of the inverter portion of the fourth exemplary UPQ unit.
- [0025] Figure 18 depicts the top cover of the inverter portion of the fourth exemplary UPQ unit.
- [0026] Figure 19 depicts the bottom end panel of the inverter portion of the fourth exemplary UPQ unit.
- [0027] Figure 20 depicts the top end panel of the inverter portion of the fourth exemplary UPQ unit.
- [0028] Figure 21 depicts the display mount bracket of the inverter portion of the fourth exemplary UPQ unit.
- [0029] Figure 22 depicts the relay mount bracket of the inverter portion of the fourth exemplary UPQ unit.
- [0030] Figure 23 depicts a mount bracket of the inverter portion of the fourth exemplary UPQ unit.
- [0031] Figure 24 depicts the splash guard of the inverter portion of the fourth exemplary UPQ unit.
- [0032] Figure 25 depicts another mount bracket of the inverter portion of the fourth exemplary UPQ unit.
- [0033] Figure 26 depicts sheet metal components of the battery portion enclosure of the fourth exemplary UPQ unit.
- [0034] Figure 27 depicts sheet metal components of the battery portion mount of the fourth exemplary UPQ unit.
- [0035] Figure 28 depicts the base of the battery portion of the fourth exemplary UPQ unit.

[0036] Figure 29 depicts the top cover of the battery portion of the fourth exemplary UPQ unit.

[0037] Figure 30 depicts the top end panel of the battery portion of the fourth exemplary UPQ unit.

[0038] Figure 31 depicts the bottom end panel of the battery portion of the fourth exemplary UPQ unit.

[0039] Figure 32 depicts the center battery bracket of the battery portion of the fourth exemplary UPQ unit.

[0040] Figure 33 depicts the relay mount bracket of the battery portion of the fourth exemplary UPQ unit.

[0041] Figure 34 depicts a mounting bracket of the battery portion of the fourth exemplary UPQ unit.

[0042] Figure 35 depicts a mounting strap of the battery portion of the fourth exemplary UPQ unit.

[0043] Figure 36 depicts a battery module mount bracket of the battery portion of the fourth exemplary UPQ unit.

[0044] Figure 37 depicts the upper right front vertical rail of the first exemplary UPQ unit.

[0045] Figure 38 depicts the lower right front vertical rail of the first exemplary UPQ unit.

[0046] Figure 39 depicts the emergency cutout (ECO) switch of the first exemplary UPQ unit.

[0047] Figures 40a, 40b and 40c depict the access to the internal batteries of the first exemplary UPQ unit.

[0048] Figure 41 depicts the inline battery bank connections of the first exemplary UPQ unit.

[0049] Figure 42 depicts the 480 and 400 volt input transformer taps of the first exemplary UPQ unit.

[0050] Figures 43a, 43b and 43c depict several display messages on the display of the first exemplary UPQ unit.

[0051] Figure 44 depicts the mounting of the internal Net Agent and DC power source and also the location of the Holjeron SDS controller of the first exemplary UPQ unit.

[0052] Figure 45 depicts configuration switches of the first exemplary UPQ unit.

[0053] Figures 46, 47 and 48 depicts the Net Agent mounting, DC power source and Holjeron SDS controller of the first exemplary UPQ unit.

[0054] Figure 49 depicts the mounting of the fourth exemplary UPQ unit to an exemplary infant warmer.

[0055] Figure 50 depicts an exemplary circuit configuration for a UPQ unit.

[0056] Figure 51 depicts the exterior of the first exemplary UPQ unit.

## DETAILED DESCRIPTION

[0057] The public need for reliable security equipment has increased after the terrorist attacks in the United States of September 11, 2001. Prior to that time, it was considered acceptable to continue using aging security equipment, such as common x-ray equipment utilizing human pattern recognition. With the recent priorities on increased security, it has become highly desirable to increase the amount of scanning of passenger luggage, detecting for example weapons or explosives, without burdening the public with excessive travel delays. As part of heightened airport security, bag scanning for all bags became law for all airports in the United States in January of 2003. New equipment was therefore sought for, not only in the United States but also for many airports and other terminals around the globe, with the capability of scanning much higher volumes of luggage. One manufacturer of such scanners is InVision Technologies Inc. of Newark, California, in the United States.

[0058] These new security devices are expensive capital equipment items. There is therefore a desire on the part of administrators to purchase as little equipment as possible to meet security needs under average conditions. It is therefore desirable to operate that equipment near capacity, and not purchase redundant systems. Under those conditions, it becomes critical to keep that equipment in operation, as a failure may lead to additional passenger delays or gaps in important security surveillance.

[0059] The most modern of security equipment includes computer equipment and other components that require a boot or "warm-up" period on start up, which may require a period of several to many minutes during which the equipment is not operational. Thus power interruptions may cause delays in the handling of passengers and luggage, which may be unacceptably long. Modern scanning equipment is also very sensitive, and power quality problems can lead to malfunctions and damage leading to costly downtime and delays. Auxilliary generators have not

adequately solved these problems because (1) a generator cannot immediately supply power due to a start-up time, which causes a power interruption during that period and (2) auxiliary generators often produce poor-quality power.

**[0060]** As mentioned above, UPS systems have been available which can mitigate power losses for short periods. UPS systems, however, may be unsuitable for use with security equipment for a number of reasons. First, a common UPS system may not filter the incoming power to remove spikes, dips and noise. Second, many common UPS devices generate a low-frequency modulated modified sine wave, which introduces some high frequency noise on the supplied power. Additionally, many UPS devices will tolerate large variations in voltage and frequency of incoming power, passing poor quality power to loads, as these devices are designed as backup devices to be brought in use only on complete power failure.

**[0061]** Herein are described Uninterruptible Power Quality (UPQ<sup>TM</sup>) devices, which not only provide battery-backed power, but also provide clean power to supplied equipment even under conditions of dirty or failed power. Depicted in figure 14 is one UPQ internal configuration. In that configuration, incoming power is first passively filtered to remove noise and spikes. That filtered AC power is then converted to DC power, in this example at no more than 170 volts. That DC power is stepped up with a DC to DC regulating inverter, in this example producing a second-stage DC voltage at plus and minus 200 volts. That power is then received by a high frequency DC to AC inverter, in this example modulated at 50kHz. The output of that inverter may produce single phase, three phase, or polyphase output. The output of the inverter is passed through another passive filter to remove the 50kHz components, which is then supplied to loads as desired.

**[0062]** A UPQ system not only conditions power, as just described, but also provides a backup supply in the event of input power failure. In the example of figure 14, the 170 VDC is supplied to a battery charger, which charges 1 or more batteries. The battery power is supplied to a separate DC to DC regulating inverter, which supplies the second stage DC power in the event of power failure from the batteries. Provision may also be made to charge batteries from an external supply, or supply the second stage DC power to the DC to AC inverter.

**[0063]** In addition, during an overload condition, a UPQ system may automatically transfer to "bypass" mode (if good power exists) to ensure that the critical load continues to receive power. The bypass function uses the AC supply power as its stand-by source. While in bypass mode, the connected equipment is still protected by filters, but the equipment is not isolated from the mains power and does not receive the benefit of voltage regulation or battery backup. The system automatically transfers back to the inverter when an overload condition has been cleared.

**[0064]** A UPQ system inverter may use a high frequency insulated gate bipolar transistor (IGBT) switched using pulse width modulation (PWM) in converting DC to AC power. This design may reduce the total number of electronic components, and make make for a lighter, smaller, more reliable and efficient system.

**[0065]** The exemplary UPQ systems disclosed herein include galvanic isolation on the output, which isolates the AC output from the input. This isolation may solve a problem of poor input grounding. Indeed, such a UPQ system may accept a different ground between the input and output, stopping current leakage through the ground. This galvanic isolation reduces the common mode noise that may be transferred to the output from the input source.

**[0066]** The exemplary UPQ systems also have an independent branch circuit for each output loop. In the event of a breaker trip or a short circuit on one of the output loops, the other output loops may continue to function, avoiding a total system shutdown.

**[0067]** The exemplary UPQ systems may also be started using internal or external batteries without an AC power source connected. Current limiting circuitry is included to protect from high inrush currents associated with DC battery connections on a dry DC bus. Those systems also include a CPU-controlled battery charger. That charger boots the charge to the batteries if the battery is degraded to a minimum voltage, which may be about 2V/cell. This boost charge allows the batteries to charge at a faster rate while avoiding exposing the batteries to high charge currents. The charger may boost charge the batteries for several hours each month automatically if desired. During the

boost charge cycle the temperature may be monitored, the charger keeping the ambient temperature below a threshold, for example 35 degrees centigrade.

[0068] The exemplary UPQ units may also automatically test the batteries. This test may occur after a boost charge, which might, for example, be performed if more than one month has elapsed from the last test. Following a test, the unit may notify a user of the battery condition and provide notification if batteries need to be replaced. By this procedure, an operator may ensure that the equipment will not be operated with failed batteries.

[0069] Referring now to figure 13, a configuration including a UPQ system is shown. That system is normally supplied with power from a utility source. A generator is also provided, whereby power may be supplied to the system by the selection of a transfer switch. A UPQ unit conditions incoming power for loads. The UPQ unit may also supply backup power using connected batteries.

[0070] A first exemplary Uninterruptible Power Quality (UPQ) unit will now be described having a 30 kVA capacity and being suitable for supplying continuous power to a CTX 9000 DSi™ explosive detection system available from InVision Technologies Inc. of Newark, California, United States. The CTX 9000 Dsi™ requires high quality power, not generally suppliable from an auxilliary generator. That UPQ unit includes power electronics in batteries in a very compact and self-contained package.

[0071] The first exemplary UPQ unit includes a cabinet as depicted in figure 51, with several system components being depicted in figures 1, 2, 3, 4, 5a, 5b, and 6 briefly described above. The unit cabinet includes four vertical rails supporting the top and sides. The upper right and lower right front vertical rails are shown in figures 37 and 38, respectively, wherein holes (or knockouts) are provided for cable feeds from the top, bottom or sides of the cabinet for input cables, output cables and interface cables. Figure 39 depicts the emergency cutout (ECO) switch of the first exemplary UPQ unit. Figures 40a, 40b and 40c depict the access to the internal batteries of the first exemplary UPQ unit. Those figures show batteries secured in racks, the racks pivoting near the rack bottoms to provide access to a rack behind. This arrangement permits access to any particular battery without



the removal of other batteries and without disconnecting both battery banks. Figure 41 depicts the inline battery bank connections of the first exemplary UPQ unit. Figure 42 depicts the 480 and 400 volt input transformer taps of the first exemplary UPQ unit. Figures 43a, 43b and 43c depict several display messages on the display of the first exemplary UPQ unit. Figure 44 depicts the mounting of the internal Net Agent and DC power source and also the location of the Holjeron SDS controller of the first exemplary UPQ unit. Figure 45 depicts configuration switches of the first exemplary UPQ unit. Figures 46, 47 and 48 depicts the Net Agent mounting, DC power source and Holjeron SDS controller of the first exemplary UPQ unit.

**[0072]** The first exemplary UPQ unit (1) protects from random or erratic power fluctuations from utility power, (2) provides pure, consistent, quality power to the equipment, (3) gives the ability to choose power backup time based on the number of battery packs used with the equipment, and (4) allows changing or servicing of batteries while the system is in operation. That unit permits several battery configurations, through which security personnel may determine the length of desired backup time by including sufficient batteries to get through that period. Even while a system is connected to either utility or generator power, that exemplary UPQ unit isolates, filters, conditions, and regulates incoming power.

**[0073]** The first exemplary UPQ unit utilizes three phase power at the input, supporting 400 or 480 volt power over four wires at 50 or 60 Hz to support most power inputs worldwide. It includes a 12 pulse DC rectifier, thereby achieving an input power factor of greater than 0.75 and preferably greater than 0.90. The unit is both Delta and Y configurable at the input and output. The unit includes independent dual internal battery banks, and multiple cable entry and exit points. Control of the unit may be provided by web based Ethernet connection, by which the unit may be monitored and shut down. In addition, the unit may be configured for SNMP. An RS232 serial port is included for control and monitoring of the unit. An array of warning and fault LEDs are provided, visible on the exterior of the unit, providing indications of several system functions, such as a low battery condition. An LCD display is included providing text warning and fault messages. The unit includes a Holjeron SDS controller for interface with the InVision equipment. An Emergency Power Off (EPO) switch is also provided for disabling the power output, and may be configured to be

normally open or normally closed, and also supports remote/relay control. The unit is air-cooled, with exhaust fans located at the top and midsection of the unit to supplement air flow. To protect from dust or particulates an intake air filter is incorporated.

[0074] When operating, a master CPU constantly monitors each system module in the first exemplary UPQ unit. Provision is made to perform PCB diagnostics. The unit may be configured by the user to auto-start if desired. Plug and play control boards are provided, which permit the unit to function in a limited capacity in the event of module failure or removal. The unit also provides inline battery isolation on shutdown. Each of the battery modules is removable for service, utilizing 100 amp Anderson disconnects per each battery bank. The unit includes an internal main breaker shutdown override, by which power may be passed-through the unit to supplied loads. The inverter, SCR and rectifier are mounted on removable rails.

[0075] The first exemplary UPQ unit includes steel construction, powder coated, and is mounted on locking casters for mobility. A unit of that type may be secured against earthquakes through stability mounting brackets. A number of UPQ units of that type may be secured together, if desired. The unit is minimally configured to supply 10 minutes of power at full load from internal batteries, with longer times configurable through additional batteries. Included batteries are preferably a maintenance free lead-acid type. A safety circuit breaker or fuse is provided for overload protection.

[0076] The first exemplary UPQ unit includes a master circuit breaker, which disconnects power from the input to the internal UPQ circuits. In that unit, a sensor senses the voltage at that breaker to discriminate a true mains power failure from a circuit breaker trip or open. If that circuit breaker is open, the connection from the batteries to the inverter is opened preventing AC output for safety.

[0077] The first exemplary UPQ unit includes a remote interface using the SDS interface protocol. Status signals may thereby be provided indicating (1) when power is being supplied from batteries, (2) when less than 50% of battery life remains, (3) whether or not the batteries are being charged and (4) an electrical fault.

**[0078]** Specifications for the first exemplary UPQ unit follow:

<b>General:</b>	
Input current (max Amp)	23
Output power capacity (VA)	10000
Output power capacity (watts)	8000
Output current (peak Amp) 3 phase output	43
UPQ power conditioning topology	Five-stage / true on-line sine wave
Nominal output voltage range (3 phase)	480V
Output frequency range	50/60 Hz
Output frequency tracking	5% of the input frequency
Output power factor	>.9
Output waveform	High resolution pure sine wave
Input power factor (12 pulse rectifier)	>.85
Input impedance of entire system	750m ohm
Input to output impedance	<5%
Remote power management	Yes
Outlets	Terminal block
<b>Voltage Regulation &amp; Frequency</b>	
Input frequency	45-65 Hz for inverter phase lock frequency range
Input range:	307 to 520 VAC
- full load without using battery	± 20%
- half load without using battery	± 25%
Output voltage regulation	±1%
<b>Isolation</b>	
Input to output isolation	Dielectric strength 5kv, 120db common mode attenuation
Common-mode noise reduction	Yes
Normal-mode noise reduction	Yes
<b>Suppression</b>	
IEEE 587/ANSI 62.41	Yes
surge let-through (North America)	Yes
IEEE 587/ANSI 62.41	Yes
surge let-through (international)	Yes

Joules (energy absorption)	2200
TVSS MOV Joule Rating	765 Joules per phase
TVSS Low pass filter	750Hz
Peak surge current	20000A
Multi-stage protection	Yes
Reverse inverter impulse protection	54 Joules without batteries
IEC	62040-2
FCC	Class A
EN 60610 (leakage current)	< 1mA
Conditioning	Yes
Output THD (linear Load)	<2%
Output frequency regulation	50/60 Hz $\pm$ 0.1 Hz
Current THD (12 pulse rectifier)	Maximum of 9%
Input frequency range	50/60 Hz $\pm$ 7 Hz
Input power factor correction	Yes
<b>High Frequency On-Line Inverter</b>	
Inverter design	Full Bridge
Inverter driver frequency	20 KHz
Inverter regulation	50/60 Hz $\pm$ 0.1Hz
Overload capacity	>110%
Crest factor	3:1
Transfer time	Zero
Overall system efficiency	93%
Rectifier efficiency	98%
Inverter efficiency	>93%
System efficiency in battery backup mode	93%
Static switch efficiency	99.5%
UPQ to bypass/bypass to UPQ	Zero cross transfer, less than 4 mSec. (2 mSec. Minimum)
<b>Rectifier</b>	
12 Pulse	6.4Khz pulse width, 80 ps for 1.7ms around 11 pulses
<b>Static Switch</b>	
Voltage range	173 VAC - 277 VAC (line to neutral)
Frequency range	45 - 55 Hz / 55 - 65 Hz

Transfer time - main to inverter	0 ms
Transfer time - inverter to main	0 ms
Transfer time - overload 100%	30 seconds
Transfer time - overload 300%	1 second
<b>Battery (standard configurations)</b>	
Full load run time (58 pcs. internal battery pack)	<10 minutes
Half load run time (58 pcs. internal battery pack)	>15 minutes
Extended battery packs	Cabinet
Recharge time	5 to 8 hrs
Battery charger	Constant voltage with current limit
Maximum recharge current (amps)	15
Boost charge	410 VDC / 415 VDC
Float charge	396 VDC / 410 VDC
Battery low voltage	320 VDC / 305 VDC
Battery low stop voltage	295 VDC / 285 VDC
Hot-swappable	Yes
<b>Temperature to altitude</b>	
Operating Temperature	0 to 50 c
Humidity	0% - 90% Non Condensing
Altitude	Less than 2000 Meters above sea level
De-rating temperature (c) altitude	4deg/1000m
<b>Physical</b>	
Q-LS WxDxH in mm	550x800x1600
Q-LS WxDxH in inches	21.7x31.5x63
Q-LS weight in Kg. (with internal battery pack)	659.39
Q-LS weight in lbs. (with internal battery pack)	1453.7
Q-LS battery pack A WxDxH in mm	550x800x1600
Q-LS battery pack A WxDxH in inches	21.7x31.5x63
Q-LS battery pack A weight in Kg.	360
Q-LS battery pack A weight in lbs.	793.66
Q-LS battery pack B WxDxH in mm	550x800x1600

Q-LS battery pack B WxDxH in inches	21.7x31.5x63
Q-LS battery pack B weight in Kg.	720
Q-LS battery pack B weight in lbs.	1587.3
Q-LS battery pack C WxDxH in mm	550x800x1600
Q-LS battery pack C WxDxH in inches	21.7x31.5x63
Q-LS battery pack C weight in Kg.	961.75
Q-LS battery pack C weight in lbs.	2120.3

**[0079]** The following tables list specifications for breaker input ratings, approximate input and output cable sizes, as well as fuse ratings and approximate cable sizes for batteries. Inadequate cable size or oversized breakers will cause risk of fire or damage. These tables should be used for reference; however, final decision as to the cable sizes should be made by a qualified electrician and in accordance with local electrical codes and regulations.

<b>KVA</b>	<b>Input</b>	<b>Maximum Current Imax(A)</b>	<b>No-Fault Breaker NFB(A)</b>
10	230/400V 3Ø	25	25
20	230/400V 3Ø	50	50
30	230/400V 3Ø	73	75
40	230/400V 3Ø	98	100
50	230/400V 3Ø	122	125
60	230/400V 3Ø	147	150
80	230/400V 3Ø	172	175
100	230/400V 3Ø	215	225
120	230/400V 3Ø	258	300
160	230/400V 3Ø	344	350

**[0080]** Cable Size for Output

<b>KVA</b>	<b>Input</b>	<b>In(A)</b>	<b>Phase A/B/C or R/S/T (mm<sup>2</sup>)</b>	<b>Phase A/B/C or R/S/T (AWG)</b>	<b>Neutral N (mm<sup>2</sup>)</b>	<b>Neutral N (AWG)</b>
10	230/400V 3Ø	18	4	12	7	9
20	230/400V 3Ø	36	8	9	14	6
30	230/400V 3Ø	54	14	6	22	4

<b>KVA</b>	<b>Input</b>	<b>In(A)</b>	<b>Phase A/B/C or R/S/T (mm2)</b>	<b>Phase A/B/C or R/S/T (AWG)</b>	<b>Neutral N (mm2)</b>	<b>Neutral N (AWG)</b>
40	230/400V 3Ø	72	22	4	30	3
50	230/400V 3Ø	90	30	3	38	2
60	230/400V 3Ø	108	38	2	50	1
80	230/400V 3Ø	144	50	1	80	3/0
100	230/400V 3Ø	180	80	3/0	100	4/0
120	230/400V 3Ø	216	100	4/0	125	250MCM
160	230/400V 3Ø	288	60(2)	1/0	80(2)	3/0(2)

**[0081] Cable Size for Output**

<b>KVA</b>	<b>Input</b>	<b>In(A)</b>	<b>Phase A/B/C or R/S/T (mm2)</b>	<b>Phase A/B/C or R/S/T (AWG)</b>	<b>Neutral N (mm2)</b>	<b>Neutral N (AWG)</b>
10	230/400v 3Ø	15	4	12	7	9
20	230/400v 3Ø	29	8	9	14	6
30	230/400v 3Ø	46	14	6	22	4
40	230/400v 3Ø	58	22	4	30	3
50	230/400v 3Ø	72	30	3	38	2
60	230/400v 3Ø	91	38	2	60	1
80	230/400v 3Ø	116	60	1	80	3/0
100	230/400v 3Ø	144	80	3/0	100	4/0
120	230/400v 3Ø	182	100	4/0	125	250MCM
160	230/400v 3Ø	232	60(2)	1/0(2)	80(2)	3/0(2)
240	230/400v 3Ø	348	100(2)	4/0(2)	125(2)	250MCM (2)
320	230/400v 3Ø	463	125(2)	250MCM (2)	150(2)	300MCM (2)
20	230v 1Ø	91	38	2	60	1
30	230v 1Ø	130	60	1	80	3/0
40	230v 1Ø	182	100	3/0	125	250MCM
50	230v 1Ø	217	150	300MCM	60(2)	1/0(2)

**[0082]** A second exemplary UPQ is intended for use in with infant incubators and warmers.

Incubators and monitors are used in hospitals to address the life support needs of premature babies.

Such equipment saves infant lives. It is reported that in some areas of the world infant mortality

exceeds 20 percent due to the lack of such equipment. Some incubators and other monitoring systems are placed in hospital delivery rooms, which may be used immediately after birth. Infants are then relocated to nurseries or other places in hospitals, requiring either the removal of infants from the equipment or the disconnection of the equipment from mains power during relocation. During this period the infant may not receive the benefit of the equipment, perhaps for several minutes at a time. For some newborn infants, particularly premature infants, this period may have an unhealthy effect.

**[0083]** That equipment may also be adversely affected by interruptions in power. A power interruption may reset the equipment, requiring an attendant to verify the state of the equipment and potentially reprogram it if required. A hospital may have a number of incubators in use, which introduces a burden on the hospital staff and also the potential for mistakes to be made.

**[0084]** Additionally, some medical environments do not have a backup source of power, for example in rural or in third-world countries. In those environments the failure of power may expose an infant to a life-threatening event.

**[0085]** A second exemplary UPQ is intended to be incorporated into the base of infant life support equipment, such as an incubator, that UPQ being shown generally in figures 7, 8, 9, 10, 11a, 11b and 12. The housing of that UPQ is narrow at the front, which defines an alignment feature for insertion into the equipment base. That UPQ provides portability for the power supply and enables the moving of vital life support equipment with the baby throughout a hospital environment. The system (1) protects from random or erratic power fluctuations from utility power, (2) provides pure, consistent, quality power to life support equipment, and (3) provides 25 to 50 minutes of (normal use) power backup time (10 to 20 minutes full load) when the life support system must be moved or in the event of power failure. That UPQ conditions the power supply of the incubator (or other equipment), which may prolong the life thereof. Dual batteries may be included; if so, one battery may be removed or replaced while the other battery supplies power for the UPQ unit with no interruption of output power. An option may be provided to communicate via a network, an IP address or dial-up connection a monitoring computer built into the UPQ unit, providing remote



monitoring and optionally control functions. The internal electronics of that UPQ unit may be similar or identical to a UPQ system manufactured by Power Innovations International, Inc. of Lindon, Utah in the United States.

**[0086]** Figure 15 depicts the rear of a third exemplary UPQ unit, which provides connections for an AC input (from mains power), output receptacles, an optional external battery connector, an optional RS-232 interface, and an optional LAN/Internet Ethernet connection for SNMP or HTTP based communication.

**[0087]** A fourth exemplary UPQ unit type is divided into an inverter portion and a battery portion, the inverter portion being shown generally in figures 16-25, and the battery portion in figures 26-36. That UPQ unit is intended to be retrofit to an existing incubator unit, as shown in figure 49. It is installable using only simple tools, ideally with only a screwdriver.

**[0088]** While UPQ units have been described and illustrated in conjunction with a number of specific configurations and methods, those skilled in the art will appreciate that variations and modifications may be made without departing from the principles herein illustrated, described, and claimed. The present invention, as defined by the appended claims, may be embodied in other specific forms without departing from its spirit or essential characteristics. The configurations described herein are to be considered in all respects as only illustrative, and not restrictive. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.